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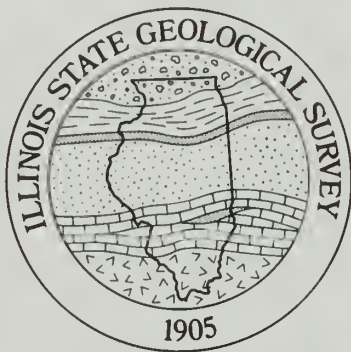


ILLINOIS STATE GEOLOGICAL SURVEY ANNUAL REPORT

July 1, 1992 – June 30, 1993

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Illinois Department of Energy and Natural Resources
STATE GEOLOGICAL SURVEY DIVISION

**ANNUAL REPORT
TO THE
BOARD OF NATURAL RESOURCES
AND CONSERVATION**

July 1992 to June 1993

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YEAR IN REVIEW

The end of FY93 marked the return of a considerable degree of financial stability to the Illinois State Geological Survey (ISGS) after major budget cuts and headcount reductions earlier in the financial year. As the year drew to a close, the General Assembly, together with Governor Jim Edgar, endorsed Senator Stanley Weaver's efforts to increase the budgets of the Scientific Surveys to fund salary increases and annualizations that were not initially included in the Bureau of the Budget's FY94 recommendations. We are deeply grateful to Senator Weaver and Senator Maitland for their staunch support throughout the hearings and the ensuing conference. We gratefully acknowledge the help of Director Jack Moore and his staff, other colleagues, and legislators who provided valuable support, and Governor Jim Edgar for signing into law the FY94 appropriation that increased the funding level 5.5% over that appropriated in FY93.

The increase of \$270,900 for FY94 personal services allowed us to grant increases and protect staff otherwise scheduled for cuts. No further reduction is needed in the General Revenue Fund (GRF) headcount for the first time in 3 years. The severe budget cuts for FY93 resulted in a reduction in our GRF budget from \$5,788,400 to \$4,920,100. Deeper cuts were threatened but avoided by strong constituency support for which we are also deeply grateful. This support helped immeasurably to restore the equivalent line items to a figure of \$5,191,000 for FY94. To this was added a new GRF line item amounting to \$85,500 for water inventory and aquifer assessment. This was formerly handled as an allocation to the ISGS from the budget for the Department of Energy and Natural Resources (ENR).

Despite the budget cuts in FY93, the ISGS was able to keep terminations to a minimum. We managed the required reduction in GRF headcount through attrition, election not to fill open positions, transfer of staff to contracts, and retirements. Nevertheless, terminations were regrettably necessary. With the ISGS program trimmed considerably and the "fat" cut from ISGS operations, some staff reductions were a natural consequence. Decisions were based on research priorities, mandated needs, demand for services, magnitude of the issue being addressed, and degree of impairment to the research by a given loss. Also considered were the Survey's mission, the balance required, and the integrity of specific projects. Relative performance also was a factor in these considerations.

The retirement of ten people in FY93 resulted in the significant loss of scientific and administrative staff whose combined contributions and efforts represented more than 225 years of Survey experience. We deeply appreciate their efforts on behalf of the Survey. This group will be sorely missed:

- James W. Baxter, Senior Geologist, 40 years
- David L. Reinertsen, Senior Staff Geologist, 37 years
- John P. Kempton, Senior Geologist, 36 years
- Richard H. Howard, Geologist, 34 years
- Alberta R. Zachay, Senior Administrative Assistant, 18 years
- Marilyn L. Farnham, Assistant Information Specialist, 16 years
- Margie D. Eastin, Administrative Assistant, 16 years
- Leona M. Whitesell, Technical Assistant II, 12 years



Chief Leighton shows a State legislative aide around the Survey.

- J. James Eidel, Principal Geologist and Branch Head, 8 years
- Joanne E. Klitzing, Administrative Aide, 8 years



Chief Leighton presents Jim Baxter, retiring head of the Industrial Minerals and Metals section, with the Lifetime Distinguished Achievement Award for 40 years at the ISGS.

The stabilization of our budget for FY94 is encouraging, both with respect to our growing needs to meet the increasing demands for earth science information and to retain and attract the qualified staff needed to carry out the mission of the Illinois State Geological Survey.

Reorganization Downsizing of the ISGS was accompanied by a reorganization that took effect December 1, 1992. The organizational structure was "flattened." Six groups, instead of the three former Branches, now report to the Chief. The groups include Energy and Mineral Resources, Geochemistry, Geologic Mapping and Framework Studies, Groundwater and Environmental Geology,

Technical Services, and Administrative Services. This change opens the channels of communication and better reflects our research and service.

Formation of the Geologic Mapping and Framework Studies group focuses effort on much needed mapping and places the ISGS in a better competitive position to seek matching funds that the federal government was authorized to provide in the recently passed Geologic Mapping Act of 1992. Recognition of Geochemistry as a separate entity once again emphasizes this research, which has helped immeasurably to give the ISGS a national and international reputation in scientific research.

The organization was streamlined and simplified by reducing the number of Assistant Chiefs and Assistant Branch Chiefs, combining four sections into two, eliminating one section, and consolidating the Survey's efforts on computerized well databases and the Geographic Information System (GIS) into one Group. The aim of the reorganization was to provide the ISGS with the flexibility to manage its affairs in the early 1990s, strengthen its capacity to attract federal and other funds, and maintain the quality of ISGS research.

Focus on Public Service The ISGS is placing added emphasis on the relevancy of its research to state needs. As a part of our mission, we are currently engaged in several



The public is invited to join ISGS scientists on four field trips per year—two in the fall and two in the spring. These trips are popular with people of all ages, and take place no matter what the weather.

projects aimed at helping the government, private, and public sectors address both economic and environmental issues. Our work on economic issues concentrates on providing industry with information and ideas to intelligently explore for, develop, and utilize the State's vast resources of coal, oil and gas, metallic and industrial minerals, and groundwater. Specific projects include the identification of available coal resources, i.e., those that can be recovered, considering the current limitations of technology, environmental constraints, and socioeconomic factors. Significant effort is also being devoted to defining ways for industry to recover more of the oil from existing fields, where recovery factors average 35% or less. We anticipate that additional effort will be spent to develop information on the distribution of the mineral resources needed to build and rebuild the State's infrastructure.

ISGS environmental research and service focuses on issues relevant to the needs of the state. Included are seven major efforts:

- reduce risks to public health and safety in the siting of new facilities,
- protect the quality of groundwater supplies,
- plan for and mitigate natural (or human-induced) disasters and hazards such as floods, earthquakes, landslides, land subsidence, radon, gas leaks, and other sources of threats to human safety,
- provide information and technologies to conserve fossil fuels and produce and use them in an environmentally sensitive manner,
- provide GIS expertise to aid public bodies, government agencies, businesses, industries, and private citizens in their planning and decision-making,
- maintain readily accessible earth science databases, collections, and information used in resolving environmental issues,
- continue our educational services to the public to help them understand their surroundings (the nature of the surface and subsurface of Illinois), and keep abreast of environmental issues.



Near Hamilton, Illinois, ISGS geologists inspect areas flooded by the Mississippi River early in July. The geological impacts of flooding will be the focus of research in the coming year.

To assist in these matters, the ISGS maintains a growing collection of well data (now covering more than 370,000 wells in the state); cuttings samples representing more than 743 million feet of drilling (more than half the distance to the moon!), core samples representing more than 1 million feet of coring; a large array of geologic maps and cross sections; and publications portraying and characterizing the geology of Illinois. Responses to many economic and environmental questions are supplied from several other databases, including statistics on the quality of coal, water, and oil; mine subsidence insurance claims; mined-out areas; a coal mine information system; and oil and gas production. Many of these databases are maintained on ENR's Geographic Information System.

This report highlights some of these activities. For a summary of the Survey's extensive activities, see the section on "Activity Measures."

Administrative and Technical Support Without the Survey's highly qualified support staff, our scientists, engineers, and management team simply could not function. Space

in this report does not allow us to give the support staff all the credit that is their due. We are proud of their record of achievement this past year.

The Business and Financial Services Unit (BFSU) added new responsibilities, taking over the business administration of the Lands Unsuitable for Mining Program from ENR. In addition, the Contracts and Grants Office was integrated with the BFSU in January 1993. The BFSU staff continues to fulfill the fundamental responsibilities of

budgeting, purchasing, vouchering, and accounting for all funds appropriated and allocated to the ISGS by the State, as well as for sponsored research funds.

The Human Resource Office undertook a yeoman's effort in handling searches using the Rutan hiring procedures to comply with the State's new hiring regulations for staff. Also completed were the paperwork for resignations, terminations, retirements, and disability leaves; status reports to the State Universities Retirement System; employment verifications, probation evaluations, worker's compensation reports, and tuition and fee waivers; tax cards, medical insurance cards, dental cards, and University of Illinois identification cards; and contract appointment requests.

Special mention should also be made of ISGS staff in the Information Office; Mail

Room; Duplicating Shop; Library and Map Room; Publications, Graphics, and Photography Unit; Maintenance, Operations, and Design Unit; Geological Records and Samples Library; Educational Extension; and the general offices of the Chief and the Technical and Administrative Groups. ISGS management, as well as scientists, are extremely pleased to be able to count these staff members as a part of the ISGS team.

Change in Report Format To go along with our streamlining efforts in other areas, we have trimmed the annual report to selected highlights of ISGS research and service. For a more readable as well as more meaningful report, we have organized it into sections that reflect the functional nature of the organization. Descriptions of some of the significant results are preceded in each section by an overview of the overall efforts underway in each functional grouping. If we can assist in interpreting the report for you or provide additional information, please do not hesitate to call on us. We welcome your views of our research and service program, which is intended to match the natural resource issues and needs of the people of Illinois.



Mary Glasgow, Human Resource Office, answers a call about employment opportunities at the ISGS.

Morris W. Leighton, Chief

ENERGY AND MINERAL RESOURCES

The characterization, assessment, economics, and environmentally responsible use of the State's mineral resources—coal, oil, gas, and industrial minerals—are the focus of ISGS research on energy and mineral resources. Some of the elements and projects within this program are highlighted in the sections that follow. Several other significant activities occurred during this report period:

- Final corrections were made on the individual and composite maps of the CUSMAP (Conterminous U.S. Mineral Assessment Program) assessments of the industrial minerals for the Paducah 1°×2° sheet. The supporting research will be published in reports that accompany the maps.
- The patent on the ISGS process for producing high surface area hydrated lime (HSAHL) was issued on June 28, 1993. HSAHL can be used to remove sulfur dioxide from gases produced by burning high-sulfur Illinois coal in dry sorbent injection systems.
- A new lot of coal, designated IBC-112, was added to the Illinois Basin Coal Sample Program in June 1993. IBC-112 makes possible the delivery of samples of Herrin (Illinois No. 6) Coal with an organic to pyritic sulfur ratio more typical of this seam than the ratio previously represented by IBC-101. The high organic sulfur in IBC-101 (70% of the total) was initially selected for projects focused on organic sulfur.
- The ISGS is providing technical support, through a subcontract with American Oil Recovery, Inc., in Mattoon, Illinois, for the Mattoon Carbon Dioxide (CO₂) Water Alternating Project. The U.S. Department of Energy (USDOE) is sup-



The scenic beauty of nature can be appreciated even in the winter where natural ice sculptures hang from a sandstone formation in southern Illinois.

porting this field demonstration of the use of CO₂ for improved oil recovery. The work includes phase behavior studies of Mattoon field crude oil and CO₂ mixtures, core displacement experiments to predict oil resources, and the development of three-dimensional geological models to aid in interpreting the continuity of Cypress reservoirs.

- More than 9,000 boxes of core from the Chicago area were donated by the Metropolitan Water Reclamation District of Greater Chicago to the ISGS. A

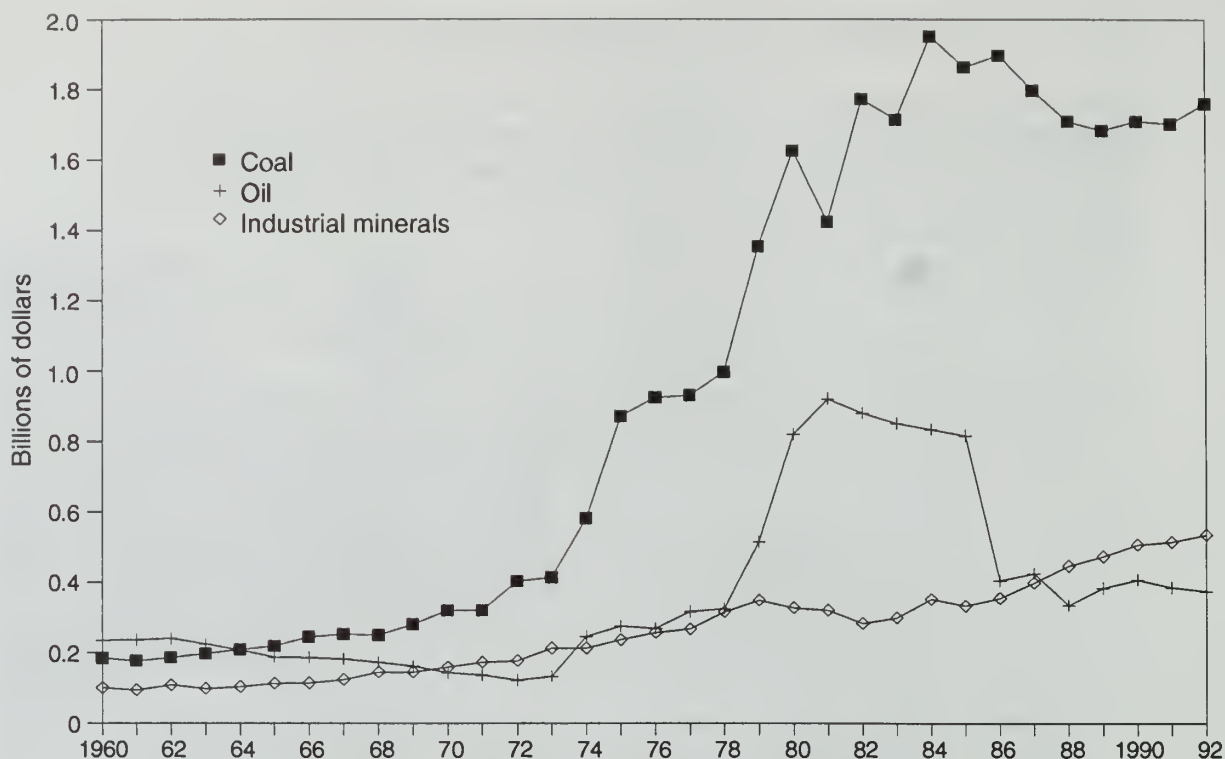


Figure 1 Values of Illinois minerals and fuels.

plan was developed to sort, organize, and store representative, nonduplicative, geographically locatable portions of this research material. The guidelines of this plan were designed to ensure the future usefulness of this valuable research collection.

ILLINOIS MINERAL INDUSTRY, 1992–93

Illinois mineral production increased by 2% in dollar value in 1992, according to preliminary data (fig. 1). Production of coal, oil, stone, and sand and gravel increased, but natural gas and clay declined. Crude oil prices slipped in 1991, while other commodities increased slightly (table 1). The U.S. economy recovered more than expected in the latter half of 1992, resulting in greater demand for electricity, transportation fuel, and construction aggregates. The anticipated rush to buy lower sulfur coal after the 1990 amendments to the Clean Air Act was slow to materialize, probably because the amendments also provided for the purchase of sulfur dioxide emission allowances. Coal production increased slightly in Illinois. The growth was mainly a result of demand from outside Illinois and overseas. In the future, however, a strong negative market influence appears inevitable for Illinois coal.

Construction aggregate production continued to grow in 1992. Stone showed stronger gains than sand and gravel. Falling interest rates were a primary factor behind the growth in demand for construction aggregates. The growth could have been greater had federal funds for highway construction been released. Demand for fluorspar, metallic minerals, clay, and fuller's earth declined.

COAL

Illinois ranks first among the states in bituminous coal resources. For the past 15 years, however, coal production in Illinois has been stagnating, despite the steady rise in U.S. production at an average rate of 2.5% per year. Illinois has been left out of the expanding

Table 1 Mineral production data for 1991 compared with preliminary data for 1992^a

		1991		1992		Percentage of change from 1991 to 1992	
Minerals extracted	Unit	Quantity	Value (\$ 1000)	Quantity	Value (\$ 1000)	Quantity	Value
Fuels							
Coal	thousand	60,036	1,702,007	60,639	1,759,744 ^b	+ 1.0	+ 3.4
Crude oil	thousand bbl	19,066	384,941	19,414	373,914	+ 1.8	- 2.9
Natural gas	thousand Mcf	466	1,011	346	743 ^b	- 25.8	- 26.5
Industrial and construction materials							
Stone ^c	thousand tons	68,586	295,362	70,800	314,000	+ 3.2	+ 6.3
Sand and gravel	thousand tons	30,446	147,610	31,221	153,053	+ 2.5	+ 3.7
Clay ^d	thousand tons	568	2,442	491	2,210	- 13.6	- 9.5
Metals, gemstones and other undisclosed ^e			83,811		65,530		- 38.7
Total value of minerals extracted			\$2,617,184		2,669,194		+ 2.0

^a Sources: U.S. Bureau of Mines and Illinois Department of Mines and Minerals.

^b Estimated by ISGS.

^c Dimension stone included with values that cannot be disclosed.

^d Excludes fuller's earth, included with values that cannot be disclosed.

^e Includes fluorspar, zinc, barite, peat, gemstones, fuller's earth, sandstone, and dimension stone for 1991 and 1992; copper, lead, silver, tripoli for 1991; no estimate for 1992.

coal market because much of its coal is relatively high in sulfur. Reserves of relatively low-sulfur coal are preferentially mined, but about three-quarters of the coal that Illinois produces contains more than 2.5% sulfur. Very little of our State's production can meet the standard of 1.2 pounds of sulfur per million British thermal units (MBtu) required for "compliance coal."

During the past year, several mines were temporarily taken out of production. In January 1993, the Monterey No. 2 Mine in Clinton County lost its contract with PSI Energy of Indiana to produce 3 million tons of coal per year through the year 2002. The mine was shut down. Although the case is in court, PSI has already found another source for its coal supplies. Sahara Coal Company, a long-term fixture of the mining industry in southern Illinois, announced the closing of its entire coal mining and preparation complex west of Harrisburg in Saline County. The United Mine Workers of America have been selectively striking mines in Illinois since May 1993. Several major producers have been affected. As a result, coal production for 1993 will probably drop significantly below the recent average of about 60 million tons per year.

Zeigler Coal Company recently became the largest coal producer in Illinois. With the acquisition of Shell Mining, a large producer of low-sulfur coal in the West, Zeigler also gained one high-sulfur coal mine in Illinois, the Elkhart Mine operated by the Turriss Coal Company. In May 1993, Cyprus Mining and AMAX Mining, parent company of another long-time producer of coal in Illinois, announced their intent to merge by the fall of 1993. The new company, Cyprus-AMAX, will take the number two position, trailing Peabody Coal and leading Consolidation Coal, in U.S. coal production. The trend continues for the major coal companies to diversify their reserve holdings.

Coal Database Management

Availability of Coal Resources in Illinois How much of Illinois' vast coal resources is actually available for future economic development? A multiyear investigation,



Geologist Russ Jacobson takes detailed field notes on the Caseyville Formation at Fern Clyffe State Park in southern Illinois.

funded in part by the U.S. Geological Survey, is expected to answer the question. Similar studies conducted in the Appalachian coal fields in recent years found that 50% or more of the original coal resource may be unavailable for mining because of environmental, legal, or technical restrictions. Factors limiting the availability of coal in Illinois are being identified and evaluated through studies of 18 to 26 quadrangles selected for mapping throughout the coal field. Evaluation of the first study area, the Middletown Quadrangle located just north of Springfield, was recently completed. The geology and physiography of this study area represent conditions found in large areas of west-central Illinois. In this quadrangle, only 55% of the resource is available for mining. Factors limiting the availability of coal are weak roof and floor rock, thin bedrock cover,

unfavorable stripping ratios, thin coal, and surface features such as cemeteries and interstate highways. Evaluations are now underway for two additional study areas: the Galatia Quadrangle north of Harrisburg and the Mt. Carmel Quadrangle in southeastern Illinois.

The results from evaluations of these study areas will eventually be extrapolated to the entire coal field. The U.S. Bureau of Mines (USBM) has agreed to use our results in their mining cost models, developed in recent years, to determine at what cost the remaining available coal resources can be mined. Planners in government and industry can benefit from this type of detailed information.

Coal Characterization

Coals Marketed by Illinois Mines The first comprehensive attempt to characterize cleaned coals marketed by Illinois coal mines began in the spring of 1992. The goal of the project, funded through the Illinois Clean Coal Institute (ICCI), is to characterize the washed coals and determine trace element concentrations by using a variety of new and advanced technical means. The results will provide a standard base line for the Illinois coal community to respond to the challenge of regulations set forth in the Clean Air Act of 1990. The availability of advanced characterization data will help promote the State's coal products in expanding global markets.

Special representative 80-pound samples of 34 washed coals from operating mines in Illinois were collected for this work. The first phase of the project included determining several characterization parameters: minor and trace element concentrations, radioactive isotopes, pyrite size distribution, maceral associations, and preliminary froth flotation cleanability. The slagging and fouling that accompany coal combustion in utility boilers called for analysis of chlorine forms and distribution as well as certain gasification and rheology parameters. Also undertaken were proximate and ultimate analyses.

Analyses of the samples were completed for 60 trace and other elements. Results indicate that the concentrations of 23 of the 28 critical elements in the washed samples are reduced to varying degrees relative to the concentrations in face channel samples from the same areas (according to available data, ISGS database). Elements reduced in

the washed coals include beryllium, chromium, manganese, cobalt, nickel, selenium, cadmium, lead, antimony, mercury, and thorium—11 of the 18 that were targeted in the legislation. The reduced elemental concentrations in the washed coals resulted from removing the mineral matter and leaching with water at preparation plants. Additional physical cleaning of these coals should further reduce the concentrations of most of the elements of environmental concern.

Computation of slagging and fouling indices indicated that the majority of the washed coals from operating Illinois mines will cause low to moderate slagging and fouling in utility boilers.

Coal Combustion

Development of Illinois Coal for Use in Coal Gasification Combined Cycle Power Production Ground was broken July 7, 1992, for a Clean Coal IV Demonstration, in which Destec Inc. of Houston, Texas, and Public Service Company of Indiana will erect and operate a 265-megawatt, coal gasification combined cycle (CGCC) addition at PSI's Wabash River plant near Terre Haute, Indiana. The CGCC technology provides the cleanest method known for the use of high-sulfur coal from the Illinois Basin. It produces more power per ton at less cost and with greater efficiency than western coal or conventional steam power, and it produces elemental sulfur for sale. The plant may be the first of many built to use coal from the basin.

The ISGS was instrumental in bringing this project to fruition. Destec was invited to the ISGS in 1989 to discuss their capabilities, needs, and long-range plans both for the operating facility in Louisiana and the demonstration plant in the Midwest. To be located near a coal producer, the demonstration facility was conceived as a joint venture with an existing power facility. Meetings were held with ENR officials, coal companies, and power companies in the state. The ISGS provided a cross section of coal concentrates made from the waste of conventional coal washing plants. Destec found the samples to be an ideal feedstock for slurry-fed gasification. A 400-ton sample of washed coal from Arch of Illinois was used in a test burn at the Louisiana plant to alleviate concerns about the effect of agglomeration or soot formation from Illinois coal. No problems were encountered. It was concluded that Illinois coal was a likely candidate for their technology.

Destec is proceeding to demonstrate CGCC technology in a \$591 million project here in the Midwest. Benefits include the use of 600,000 tons of Illinois Basin coal per year, and more than 100 full-time positions added to area payrolls. The ISGS has contributed significantly to the arrival of CGCC technology in the Midwest.

Full-Scale Demonstration Test of High Surface Area Hydrated Lime (HSAHL) at Illinois Power's Hennepin Station In July 1992, ENR and the Illinois Clean Coal Institute (ICCI) requested that ISGS provide about 45 tons of ISGS patented HSAHL for a full-scale demonstration at the Hennepin plant. The project was sponsored by the USDOE, ENR, and Gas Research Institute. The ISGS identified and provided technical assistance to a Georgia chemical firm, Optima Chemicals, which made the products.



Kristi Brewer, technician in the coal lab, sets the ion chromatograph that tests the fluorine levels in coal samples.



Dave Moran and Tony Lizzio, chemical engineers, and Jimmie Cooper, craftsman, inspect the newly patented high surface area hydrated lime equipment. The lime is used in a process that can remove sulfur dioxide from gases produced when burning Illinois' high-sulfur coal.

The ISGS also supplied technical data for safe handling and storage of the HSAHL to Illinois Power and the Energy and Environmental Research Corporation (EER), the organization conducting the tests at Hennepin. A combustion test matrix was also prepared and the test results analyzed for EER. The tests took place in January 1993. Results:

- Scale-up of the HSAHL process involved no technical risks.
- HSAHL removed 40% to 45% more sulfur dioxide than a commercial hydrate.
- With 18% gas reburning, HSAHL achieved 50% and 75% sulfur capture (as required by the Clean Air Act for 1995 and 2000, respectively) at calcium to sulfur ratios of 1 and 2.
- Sulfur capture was independent of boiler load (45 to 70 megawatts).
- Using HSAHL in a commercial dry sorbent injection system produced no operational problems.

The HSAHL was also tested by Consolidation Coal Company (Library, Pennsylvania) in its duct sorbent injection (Advanced Coolside) process. Preliminary results indicated that by recycling the sorbent, sulfur dioxide could be reduced by more than 95% at a calcium to sulfur ratio of 1.4.

OIL AND GAS

Fifty-one Illinois counties produce oil from more than 32,000 stripper wells. Illinois reservoirs are complex and offer excellent research opportunities to determine how to best manage the reservoirs to maximize recovery efficiency. ISGS oil and gas research aids the industry and the economy of southern Illinois by

- defining the reservoir architecture in selected fields to be used as analogs by operators
- recommending existing technologies that may improve recovery
- examining the potential for advanced recovery technologies
- transferring knowledge of the reservoirs in the state to industry
- providing a database of information necessary to industry.

Current low oil prices and a 57% loss of jobs between 1982 and 1989 have hurt the industry. Income and other taxes from oil and gas activities have declined by more than two-thirds in the last decade. Illinois' discovered fields still contain considerable oil—nearly 1.5 billion barrels of mobile bypassed oil and another 3.4 billion barrels of immobile, residual oil. Illinois ranks eighth in remaining oil in place among the lower 48 states. Given an average recovery of only about 35% from Illinois' discovered fields, a sizable target exists for additional recovery. In view of this potential target, the ISGS expanded its oil and gas research and technology transfer activities in the past few years. Now it is recognized nationally as an outstanding program. Demonstrations of reservoir models, seismic data acquisition, new log interpretations, and advanced reservoir description should provide additional information necessary for the industry to recoup and for the state to ensure optimum recovery of a valuable resource.

In 1992, 989 new test holes were drilled in Illinois: 486 new oil, 13 new gas, 168 reworked dry holes (now oil), and 2 reworked dry holes (now gas); 320 were dry holes.

Improved Oil Recovery Methods and Concepts

Reservoir Characterization A 4-year research project, cosponsored by the Illinois ENR and USDOE, consisted of studies aimed at providing information on geologic and other factors controlling oil production from Cypress and Aux Vases reservoirs in Illinois. Results of six studies have been published and several more are in press; the rest of the studies are in peer review or nearly complete. Technology transfer activities included scores of technical presentations at professional meetings, and publication of papers and abstracts in technical journals and conference proceedings. Three ISGS publications from this project were produced during the past year.

Reservoir Characterization and Improved Oil Recovery from Multiple Bar Sandstones, Cypress Formation, Tamaroa and Tamaroa South Fields, Perry County, Illinois (ISGS Illinois Petroleum 138) Oil recovery,

ranging from 5% to 43% in the compartmentalized Cypress sandstones, was controlled in these two fields by several factors: reservoir architecture, formation damage, and most importantly, reservoir management. The study demonstrated how changes in production strategy in these sandstone bars will help recover more oil. About 600,000 barrels may still be recoverable in these fields.

Reservoir Characterization and Potential for Improved Oil Recovery within the Aux Vases Formation at Stewardson Field, Shelby County, Illinois (ISGS Illinois Petroleum 139) Sandstones in the Aux Vases Formation at Stewardson Field exhibit less porosity and permeability than other Aux Vases reservoirs studied in the state. Unlike many Aux Vases sandstone reservoirs that are interpreted as shallow marine bars, this



Steve Sim, petroleum engineer, makes a few adjustments to the state-of-the-art apparatus that is used in the laboratory to duplicate oil production conditions.

reservoir is interpreted as a subtidal shoreface sheet sandstone. Recovery efficiency at Stewardson Field averages 18% across the entire field, but averages 42% in the part of the field that is on a paleotopographic high. The recoveries peripheral to the old high are lower as a consequence of slightly higher contents of finer materials (silts and clays) and cements in the sandstones in these areas than in the sandstones on the paleo-high. Recoverable reserves in Stewardson Field are estimated to be 83,800 barrels of oil, and the field shows potential for future development.

Pressure–Volume–Temperature Correlations for Crude Oils from the Illinois Basin (ISGS Illinois Petroleum 140) Analyses of pressure, volume, and temperature (PVT) were performed using crude oil and gases from three different Illinois reservoirs. The results were used to evaluate the applicability of the commonly used correlation methods for PVT properties and to validate an equation of state (EOS) computer program that can be used to calculate PVT properties under other pressure and temperature conditions. Improved correlations for calculation of PVT properties for use in reservoir management were made available from this study. Improving the correlations will extend their applicability as more PVT data become available. PVT correlations are used to estimate the volume of original oil and gas in place, calculate flow properties in the reservoir or in pipelines, and provide the necessary data to allow an operator to provide pressure maintenance in the reservoir at an appropriate time.

Effects of Clay Minerals on Recovery of Petroleum from Aux Vases and Cypress Reservoirs in Illinois Detailed X-ray diffraction and scanning electron microscope analyses of various size fractions of samples from the Aux Vases and Cypress reservoirs led to an improved methodology for clay mineral analysis. Applications of this method resulted in the discovery of both physical (crystallographic) and chemical (iron:magnesium) variations within chlorites from these reservoirs. The impact of these variations on oil production warrants further study.



Dewey Moore, clay mineralogist, prepares clay samples for X-ray diffraction.

OTHER ENERGY SOURCES

Unconventional Resources

Coal Bed/Mine Methane Resources The ISGS continues to supply vital information on coal mine and coal bed methane resources to industry and private parties attempting to evaluate the potential for gas production in Illinois. Information supplied generally consists of analyses of the amount and quality of coal bed gas, thickness and depth of coal seams, and maps of abandoned coal mines. The ISGS compiled an informational handout of data assembled from various reports and lists of coal bed and coal mine methane related publications, active operators involved in the exploration, and wells drilled into abandoned mines. Currently, nine operators have drilled into abandoned coal mines in Christian, Franklin, Marion, Montgomery, Saline, Sangamon, and Williamson Counties in exploration for coal mine methane. These exploration activities indicate the birth of a new but limited, energy-producing industry within Illinois. Since 1980, two abandoned coal mines in Saline County have produced a cumulative total of more than 700 million cubic feet of gas.

MINERAL ECONOMICS

Critical Trends

Critical Trends Assessment Project As part of an effort to assess the environment of Illinois, ENR sponsored the Critical Trends Assessment Project (CTAP). The ISGS portion of the CTAP was funded with \$125,000 for the period of July 1, 1992, to June 30, 1993. The CTAP can be looked at as a precursor to the proposed effort of the U.S. Environmental Protection Agency (USEPA) to monitor trends critical to the future of the environment. There are two fundamentally different approaches: one approach involves the definition of critical environmental factors and units to measure them, followed by a systematic monitoring and evaluation of the observed trends. The other approach is to begin with factors measured or monitored in the past and estimate their future environmental impact. With an appropriate level of flexibility, the latter approach also permits conclusions regarding factors that need monitoring now, although they were not monitored in the past. Illinois' approach resembles the latter.

The ISGS portion of the project was designed to cover the following goals:

- Provide insight into the geologic foundations of the environment by illustrating the connection between earth resources and land use.
- Study the trends in earth resource production and consumption, and assess their environmental effects.
- Provide an overview for management of wastes generated by the use of earth's resources.

Additional objectives were to test the adequacy of available databases and pinpoint factors for future data collection. The study indicated several desirable changes and additions to available databases.

- Data availability varies in quality, form, and time. Some factors such as coal production have been monitored for 100 years, and others for only a decade—or not at all.
- Technological changes such as renewable energy, nuclear power, and telecommunications could make some factors that were significant to the environment in the past, irrelevant at present. New factors are also likely to be added to the list of those to be monitored.
- Databases on generation, management, and disposal of wastes by the mineral industries need significant strengthening.
- Data on the quality, quantity, and location of earth resources have become important in view of urban expansion and future technologies. The information will aid planning to prevent improper land use and protect resources from becoming unminable.



Mineral economist Subhash Bhagwat checks statistics collected and compiled by Irma Samson for her annual report on the Illinois mineral industry.

GROUNDWATER AND ENVIRONMENTAL GEOLOGY

Important missions of the ISGS are to address issues of natural and cultural hazards, help locate and protect groundwater supplies, and devise means to mitigate environmental problems that involve the earth sciences. The ISGS cooperates with the Illinois and Federal Emergency Management Agencies to identify natural hazards and develop mitigation strategies for serious, unpredictable situations such as landslides, earthquakes, and floods. (Geological aspects of the 1993 flood along the Mississippi and Illinois Rivers will be reviewed in our next annual report.) During the report period, we provided technical support for regional earthquake education. An earthquake risk map, now in preparation at the ISGS, will assist in establishing uniform policies for

earthquake preparedness for Illinois, Indiana, Kentucky, and Missouri. The Illinois Mine Subsidence Research Program, a cooperative federal and state project that began in 1985, is receiving some support from the Illinois Clean Coal Institute (ICCI) for publishing final reports. The coal mining industry is showing interest in a special publication on longwall mining and planned subsidence—a booklet explaining to landowners what happens to the land overlying a longwall mining operation.

Regional groundwater studies to help locate and protect groundwater resources are being conducted in cooperation with the Illinois State Water Survey in Tazewell and other counties. Investigations directed toward preventing contamination of our groundwater supplies by agricultural chemicals are a major emphasis of the ISGS groundwater protection project. Through research supported, in part, by the Illinois Department of Agriculture and Illinois Environmental Protection Agency, the ISGS is studying how various agrichemicals travel through soils and how soils affect the adsorption and degradation of common pesticides.

Leadership, planning, and proposal review are provided by ISGS staff in support of the Illinois Groundwater Consortium and the Midwest National Mined Lands Reclamation Program.

A continuing problem is the provision of resources, particularly the experienced staff to carry out fundamental investigations as well as to expand and manage databases that not only sustain research but keep us prepared to deal with emergencies. Special tasks such as the Low Level Radioactive Waste (LLRW) siting study are dependent upon the continuation of fundamental research. Environmentally sound decisions require input from multiple disciplines. Both the scientific information and the expertise required to interpret it are keys to sound, geologically based environmental decisions.

GROUNDWATER

Groundwater Resources

Hydrogeology of the Danville Area (ISGS Open File Series 1993-9a) An inadequate water supply during droughts and high nitrate concentrations in the drinking water made it necessary for Danville, which obtains its water from Lake Vermilion, to look to groundwater to supplement its water supply. The ISGS assisted in establishing the hydrogeologic framework of the glacial drift aquifers in the Danville area and in assessing the potential of the groundwater resource to supplement the city's water



Mike Barnhardt, geologist, measures the water level in a monitoring well near an agrichemical plant.

supply. Aquifer maps were updated, and recommendations for groundwater resource exploration were made. On the basis of this work, Inter-State Water Company is conducting additional geophysical work as the next phase of developing a supplemental source of water supply for Danville.

LAKES, STREAMS, AND WETLANDS

Wetlands

Illinois Department of Transportation Wetlands Project The IDOT-sponsored Wetlands project was a primary focus of the ISGS wetlands studies during the report year. The multifaceted project has a primary long term goal: to develop hydrogeologic databases on the geomorphic setting of existing, restored, and constructed wetlands. Short term goals of the project are to characterize and monitor wetland mitigation sites from a hydrogeologic perspective. IDOT will use the data to site wetlands, design criteria for wetlands, and evaluate the success of constructed wetlands. At present, studies of 15 sites are underway. One of the wetland study sites near the Hannibal River bridge is now flooded. The location is excellent for examining the effects of flooding on wetland areas.

Lake Michigan

Monitoring Littoral Transport Processes at Coastal Development Projects Along Lake Michigan Large coastal engineering projects can alter the sediment transport processes and cause local and regional accretion or erosion along the coast. Changes in the beaches and lake bottom near such projects must be monitored to guide remedial actions taken to reduce adverse coastal impacts. The ISGS is monitoring two coastal projects along the Illinois shore of Lake Michigan. At North Point Marina in Winthrop Harbor, 5 years of coastal monitoring has been completed. The Illinois Department of Conservation uses the database to mitigate the effects of erosion and to plan and design beach nourishment. Along the coast at Lake Forest, the ISGS is assisting in monitoring at Forest Park Beach, a state-of-the-art shore protection and recreational facility.



Hydrogeologist Dave Larson and geologist Jim Miner check a monitoring well as part of an IDOT-sponsored study of wetlands near the Mississippi River bridge at East Hannibal, Illinois. The well was flooded a few weeks after this picture was taken. The location is excellent for studying the effects of flooding on wetlands.

HAZARDS REDUCTION AND MITIGATION

Landslides

Landslide in Peoria County The ISGS is assisting the Abandoned Mined Lands Reclamation Council (AMLRC) in monitoring a landslide that damaged two homes in the Peoria area. In January, the AMLRC was contacted by the owners of two houses



Dan Van Roosendaal, geological engineer, uses a plumb-bob while working on an IDOT project near Galatia, Illinois.

damaged by ground movements. The landslide had a 2-foot displacement of the uppermost scarp. Scientists suspected that the homes were being damaged by subsidence associated with coal mine subsidence. The AMLRC started monitoring elevations of the ground surface and asked the ISGS to determine instrumentation, drilling specifications, and monitoring needs, as well as to assist with the interpretation of movements in the area. The ISGS, together with the AMLRC, installed two inclinometers above and below the 2-foot high scarp at the top of the landslide. This instrumentation, which monitors the movement in the soils and bedrock, showed that the failure plane for the slide is located near the soil-bedrock contact. Additional

instruments were installed to measure possible separation taking place in the bedrock, which would indicate subsidence from the underground coal mine. If coal mine subsidence is taking place, it may have triggered the landslide.

Subsidence

Subsidence and Hydrologic Effects of a Shallow Longwall Coal Mine Operation ISGS engineering geologists installed instruments in the ground overlying one of the shallowest longwall coal mines in the state. The mine is 330 feet below the ground surface. The instrumentation will document ground surface movements and ground-water responses in the bedrock and glacial material. Undermining of the site and associated subsidence occurred in January 1993. Ground surface movements showed nearly 5 feet of subsidence. Water level measurements are being compiled and analyzed.

Sinkholes

Formation of Sinkholes in Karst in Southern Illinois: Identification and Interpretation of Associated Buried Cavities Sinkholes formed in Dongola, a village in southern Illinois (Union County), in the spring of 1993 during the construction and development of a new municipal well. The well and a companion test well were drilled through clay-rich, valley-fill sediment into karstified limestone bedrock. Three cover-collapse sinkholes formed on the playground of the Dongola Unit School during pumping of the well. At the well head, the piezometric surface of the groundwater in the limestone bedrock was above land surface and indicated an upward hydraulic gradient. Pumping the well lowered the piezometric surface of the limestone aquifer to an elevation below the base of the valley fill. The hypothesis is that the resulting loss of hydrostatic pressure and buoyancy within the sediments, and the initiation of groundwater flow toward the well resulted in rapid sediment transport, subsurface erosion, and collapse of the unconsolidated, valley-fill sediment. The sinkholes appear to follow an approximately east-west alignment, which is similar to that of nearby caves. A constant electrode-separation resistivity survey of the recreational areas near the school revealed an

anomaly trending N75°E in the southern part of the study area. The anomaly is linear, about 5 to 10 meters wide, and its trend either intersects or is immediately adjacent to the three sinkholes. The anomaly is interpreted to be a series of pumping-induced soil domes (buried precollapse features) in the valley-fill sediments overlying a preexisting crevice in the karstified bedrock limestone. The well was permanently shut down as a result of recommendations by the ISGS.

SITING ASSISTANCE

Waste Facilities

Locating a Site for a Low Level Radioactive Waste Facility The State of Illinois spent almost \$90 million between 1986 and 1992 in an unsuccessful attempt to site a LLRW facility at Martinsville. The General Assembly has amended the Low Level Radioactive Waste Siting Act so that science, rather than politics, plays the lead role in identifying sites for a facility. To this end, the General Assembly directed the Illinois State Geological and Water Surveys to identify ten locations that may meet siting criteria, as determined by a Governor's Task Force.

The two surveys prepared criteria relating to geology, hydrogeology, and hydrology for consideration by the Task Force. Both site criteria (site goals) and screening criteria (which serve as site goals during the screening process) were suggested for identifying areas likely to meet the siting criteria.

A plan prepared for the Illinois Department of Nuclear Safety called for the identification of at least ten

(below) Geophysicist Paul Heigold, geologist Pius Weibel, and hydrogeologist Sam Panno examine a water-filled sinkhole that appeared on the Dongola Unit school playground in Union County, Illinois. At right they measure the resistivity in the sediments above bedrock where the sinkholes formed. As technical information officer, Sue Muckensturm (above right) will write the story for the media release.



potential locations within 18 months of the adoption of criteria by the Task Force. The plan provides for a start-up period, while the siting criteria are established, and for support of the siting task force's efforts. Existing maps and databases in the Geographic Information System (GIS) will be used during the screening. Most maps are at the 1:500,000 scale, although some such as the stack unit map are at the 1:250,000 scale. Regions of 10 to 30 square miles, which appear to meet the criteria at the 1:500,000 scale, will then be scrutinized at the 1:100,000 scale by adding well log, chemical, and other data sets. Once detailed review of all available data indicates areas that would still meet siting criteria, studies will begin. Field techniques will include drilling, geophysics, well inventory, and geologic mapping. Ten locations must be transmitted to the siting task

force for its review. The law also requires the Surveys to review any site proposed by local government or industry, and to compare these "volunteered" sites to the established criteria.



Engineering geologist Chris Stohr, geological engineer Dan Van Roosendaal, and technical assistant Mark Hart assess the data gathered for an ongoing environmental property assessment for IDOT.

Highways

Environmental Property Assessments for IDOT

In the fourth year of this statewide project for IDOT, 122 reports representing more than 200 miles of state highway projects were completed. Projects ranged in length from a single parcel to more than 16 miles. In October 1992, an interim reporting format was initiated to rapidly provide IDOT with information appropriate to early planning stages of highway construction projects; 161 interim reports have since been provided to IDOT.

DATABASE ENHANCEMENT

Base Line Studies

Statewide Soil Sampling and Analysis for Major, Minor, and Trace Elements In conjunction with the IDOT property assessments project, the ISGS is collecting base line information on naturally occurring concentrations of elements in soils. The data will help in distinguishing between hazards due to natural conditions and hazards due to human activities. Not much information has been published on this topic. To date, ISGS has collected 188 samples throughout the state. The samples were divided and analyzed for major, minor, and trace elements. Among the elements found were several potential contaminants: arsenic, beryllium, cadmium, cobalt, chromium, copper, manganese, nickel, lead, antimony, selenium, and zinc. This sampling program will provide much needed base line data for some of the areas flooded this past spring and summer along the Mississippi and Illinois Rivers.

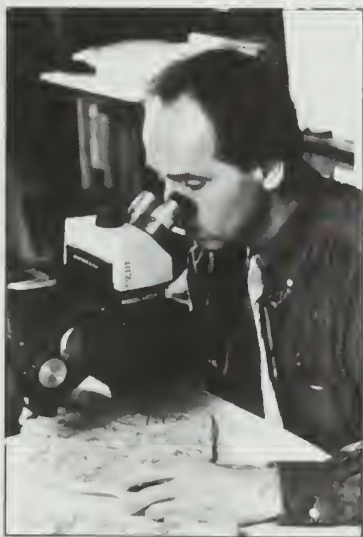
Database Verification

Field Verification of Landfills and Special Waste Sites: Cooperative Agreement with the Hazardous Waste Research and Information Center A critical element in the IDOT property assessment studies is the accurate location of landfills and special waste sites that might affect the acquisition of rights-of-way. The ISGS and HWRIC initiated a cooperative program in which field-verified locations of such sites are provided to HWRIC for incorporation into their GIS databases. Currently, locations of these sites may be listed in the database only to the nearest township or center of a municipality. The site locations are field-checked by ISGS geologists and plotted on a map. The information is returned to HWRIC so that they can improve the accuracy of their databases.

GEOLOGIC MAPPING AND FRAMEWORK STUDIES

Geologic mapping and stratigraphic, structural, geophysical, and paleontological investigations provide basic knowledge and the framework upon which many mineral resource, groundwater, environmental, and engineering studies are based. Geologic maps and three-dimensional geologic models portray the distribution, character, and age of geologic units. Stratigraphic cross sections of Quaternary glacial deposits and Paleozoic sedimentary rocks provide a basis for defining mappable units on geologic maps and reveal stratigraphic and structural information. Geophysical studies of the nature of the deeper crust provide information about the deep structures that now influence earthquake activity. In the past, these structures controlled the origin and development of the Illinois Basin and surrounding domes and arches, and affected the distribution of mineral resources. Paleontological and palynological studies provide information and evidence needed to (1) support stratigraphic correlations and relative age determinations and (2) offer significant guidance in understanding depositional environments and interpreting paleoclimates. Computers and GIS technology provide a means of manipulating, visualizing, and spatially analyzing the large geoscience data sets required for basic and applied studies. Specialized software and plotters also assist in the production of printed maps and cross sections. Some significant activities occurred during this report period.

- Significant progress was made in mapping the geology of the Tamms and Dongola 7.5-minute quadrangles in southern Illinois and, as one activity of the Tradewater Working Group, in mapping the distribution of the Block Coal.



Dennis Kolata, geologist, examines Mississippian-age crinoids under a microscope. Fossil studies give us vital information about life in past geologic periods.



Ardith Hansel, geologist, examines glacial sediments at the Wedron Quarry.

- Work is nearly complete on the revision of the glacial stratigraphy of the Wisconsinan, the last major glaciation. This revision will provide a consistent stratigraphic framework for mapping and stratigraphic studies in northeastern Illinois.
- Research funded by the National Science Foundation continues on the genesis of subglacial till as a means to model the dynamics of the Laurentide Ice Sheet during the last glaciation, reconstruct the paleoclimate, and understand the sediment record.
- Work continues on the construction of cross sections that will show the structural and stratigraphic framework of the Illinois Basin.
- Study of recently acquired drill cores from east-central Illinois show that the Mt. Simon Sandstone (Cambrian), a major aquifer and an ancient conduit for ore-forming fluids, was deposited in a widespread, tidally dominated environment. The information will be useful to companies seeking sites for natural gas storage.

ILLINOIS STATE
GEOLOGICAL SURVEY
LIBRARY

- New interpretations of tectonic data show that the Ozark Dome, a major structural feature in east-central Missouri and southwestern Illinois, had a long history of uplift, faulting, and folding that influenced the distribution of mineral resources.
- Volcanic ash beds deposited in wide areas of the northern hemisphere, including Illinois, have significant implications in the search for mineral resources. The beds provide accurate reference marks for the timing of geologic events. The scientific community is also interested in the possible effects of these large ash falls on global extinctions.
- Significant progress was made in curating the Charles Collinson conodont collection and the Richard Liebe collection. A curatorial plan identifies the collection location and number of species, details locality information for each species, and outlines procedures for using and donating to the collection. A relational computer database was constructed to facilitate access to information on the ISGS collections.

GEOLOGIC MAPPING

Development of Methodology

Champaign 30×60-Minute Quadrangle, Central Illinois The purpose of this 3-year demonstration project, conducted in cooperation with the USGS, is to produce a "three-dimensional" map that represents a complex succession of geologic materials from land surface through the bedrock surface. The project will better define the complex glacial stratigraphy of the area, demonstrate a methodological approach for future "three-dimensional" mapping under the National Geologic Mapping Program, and provide data needed to further delineate the groundwater resource potential of the Mahomet Aquifer. Project staff have identified and digitized key stratigraphic control data and developed a new bedrock subcrop map.



ISGS geologist Myrna Killey and intern Randy Locke (foreground) describe and log a core sample. John Kempton (standing right), geologist, explains the Champaign Quadrangle mapping project to Bob Wathen, editor, writing a story for the ISGS newsletter.

County Geologic Mapping

McHenry County This geologic mapping project, entering its third and final year, is designed to delineate the geologic and hydrogeologic framework of the county at a level of detail useful for county decision-making. It will provide information on the geologic distribution of aquifers and the potential for groundwater contamination. The available data from all 15 of the 7.5-minute quadrangles covering the county were compiled and evaluated. Available logs from water wells and test borings were evaluated and plotted, stratigraphic relationships were determined, and more than 40 cross sections were constructed. Twelve test borings were drilled to depths up to 250 feet, and piezometers were constructed in deeper holes. Samples of till were analyzed to determine particle size content and clay mineral compositions.

Geologic Mapping and GIS Screening for County Landfill Site Identification Cooperation with the ENR Offices of Recycling and Waste Reduction and Research and Planning is central to this project, which provides county governments with geologic mapping and other technical assistance for landfill site identification. Maps, cross sec-

tions, and other data are presented to county officials and the public to increase awareness of the importance of geologic factors for landfill siting decisions and to educate those groups about the geologic setting of their counties. The first project was undertaken for Champaign County in 1989 to 1990. Successive efforts have been in Lake, Will, and McLean Counties.

Staff prepare maps showing subsurface sand and gravel units that are potential pathways for migration of landfill leachate. The GIS computers are used to compile data sets from ISGS archives, analyze information, and prepare maps and cross sections. Final maps for Will and Lake Counties include Generalized Land Surface Topography, Topography of the Bedrock Surface, Thickness of Quaternary Deposits, and Sand and Gravel Isolith. Other products were cross

sections and a series of "slice" maps showing the distribution of coarse grained and fine grained materials in 50-foot "slices" from the ground surface to bedrock. Work is also underway for McLean County. Potential projects include mapping for Carroll, Henderson, Union, Johnson, Pope, Hardin, Alexander, Pulaski, and Massac Counties.



Geologist John Nelson and driller Tim Young retrieve a core sample for a mapping project in southern Illinois.

Quadrangle Geologic Mapping

Southern Illinois Post-Cretaceous tectonic faulting has long been suspected in the Mississippi Embayment area of southernmost Illinois, but previous studies failed to confirm its presence. New mapping under a cooperative mapping program involving the ISGS and USGS uncovered definite evidence of post-Cretaceous faulting in three areas of southernmost Illinois. In the Jonesboro and Mill Creek Quadrangles (Alexander and southern Union Counties), Upper

Cretaceous and Eocene sediments are displaced by high-angle faults that trend north, northeast, and east. Preliminary mapping in the Mermet and Reevesville Quadrangles, northern Massac County, revealed apparent displacement of the Mounds Gravel (Pliocene to early Pleistocene age) along northeast-trending faults. Concurrently, USGS geologists mapped northeast-trending faults that deform the Mounds Gravel and older units in the Thebes Quadrangle (Alexander County, Illinois, and Scott County, Missouri). In all of these areas, the displacements appear consistent with the contemporary tectonic stress regime of southern Illinois and the New Madrid Seismic Zone. Studies on the faulting will continue to assess whether Quaternary deposits are involved and what degree of seismic risk, if any, these faults pose to inhabitants of the region.

BASIN ANALYSIS AND GEOPHYSICS

Deep Seismic Reflection and Refraction Studies

Deeply Buried Crustal Boundary in Southern Illinois: Its Role in the Evolution of the Illinois Basin and Modern Earthquake Activity ISGS scientists discovered that a major crustal boundary crosses North America from the Rocky Mountains to southern Illinois to north-central Tennessee. The boundary, which lies about 20,000 feet below the surface, was detected during analysis of gravity, magnetics, seismic reflection and refraction, drill hole, and outcrop data. The boundary lies along the projected trend of the north margin of the Central Plains Orogen, suspected to be a convergent margin



ISGS geologists examine a 20,000 year old spruce forest that was buried by proglacial deposits of the last glaciation. Leon Follmer, paleopedologist (lower right), checking the lay of the land near Charleston Quarry where the buried forest is being studied.

where two continents collided and accreted during the Early Proterozoic, 1.8 to 1.6 billion years ago. Reactivation of the boundary and the associated zone of weakness during Paleozoic time apparently influenced the structural development and configuration of the Reelfoot Rift–Rough Creek Graben situated at the southern end of the Illinois Basin.

The boundary also appears to be influencing modern seismicity. In southeastern Illinois and western Kentucky, it separates two seismically active regions, the Wabash Valley Seismic Zone and the New Madrid Seismic Zone. Although these two zones appear to be geographically aligned and have been subjected to similar regional stresses in recent times, the historical record of Midcontinent earthquakes indicates that a far greater amount of strain energy has been released in the New Madrid Seismic Zone. The New Madrid Seismic Zone corresponds to the Reelfoot Rift, which has had a structural development quite unlike the Wabash Valley Fault System, the apparent structural counterpart of the Wabash Valley Seismic Zone. If these two seismic zones actually lie in different tectonic provinces, the different magnitudes assigned to design earthquakes in these seismic zones (body wave magnitudes 6.2 for the Wabash Valley Seismic Zone and 7.2 for the New Madrid Seismic Zone) may be justified on more grounds than historical seismicity. Results of this ongoing research were published recently in the international journal, *Tectonophysics*. Current research is focusing on the age and cause of seismicity within and around the crustal boundary.



Potential Field Investigations

Geophysical Map Publication The ISGS published two significant geophysical maps in its new Illinois Map series: *Simple Bouguer Gravity Anomaly Map of Illinois* and *Total Intensity Magnetic Anomaly Map of Illinois*. These complementary, potential field maps indicate lateral density and magnetic susceptibility variations in the rocks of the earth's crust and upper mantle. Variations can be related to the structure and composition of these rocks. Such information is extremely useful in the exploration for hydrocarbons and mineral deposits and in understanding the evolution of the crust and upper mantle in and around Illinois. The statewide total intensity magnetic map, compiled as a joint USGS/ISGS project, is particularly noteworthy. It is the first of its kind for Illinois.

GEOCHEMISTRY INVESTIGATIONS AND SERVICE

Organic, inorganic, and isotope geochemistry, and geomicrobiology, the disciplines covered by Geochemistry Investigations and Service, are being applied to pesticide research, environmental geochemistry, and exploration geochemistry.

- Analytical methods for the determination of pesticides in soils and waters were compared in research conducted by chemists at the ISGS and Southern Illinois University at Carbondale (SIU-C). The two research groups produced comparable results, but certain analytical procedures were shown to require more development and refinement.
- Research on the contribution of atrazine from a cultivated field to an adjacent river was completed and reported. Essentially, no atrazine was carried into the river by groundwater recharge. Most of the atrazine was degraded, adsorbed by soils, or transported in tile-drainage waters.
- The characterization phase of a joint research project with the Department of Landscape Architecture at the University of Illinois on the persistence of pesticides on turf grass was completed. Findings of the project were that pesticide residues were persistent on turf grass clippings, suggesting that yard waste composting at municipal sites should be tested for leachates and runoff. Funding for the project was not renewed.
- Research on the microbial degradation of atrazine found that the half-life of atrazine is 2 to 4 weeks under anaerobic conditions.
- The database on indoor radon in Illinois continued to expand, allowing the ISGS to generate a low resolution map showing the distribution of indoor radon in Illinois. A report was written for the Critical Trends Analysis project.
- Chapters on the characterization and environmental impacts of coal combustion residues were contributed by ISGS geochemistry staff to a literature review on the disposal and utilization of these residues. The review was funded through the Coal Combustion Residue Management program administered by SIU-C.
- An analytical method to determine organic compounds in geologic solids by pyrolysis-mass spectrometry is showing promise.
- Stable isotope geochemistry is being used to determine the origin and age of groundwater in the Mahomet Valley aquifer.
- Sediments from the Grand Calumet River were analyzed for major, minor, and trace element composition to determine the degree of contamination of the sediments. The rate of sedimentation during the past 40 years was determined by means of the activity of cesium-137 in the sediments.
- Several Illinois crude oils of Ordovician age were identified by gas chromatography-mass spectrometry.
- Coal, soil, rock, and water were chemically analyzed for their organic and inorganic constituents. Several techniques were used, including gas chromatography, gas chromatography-mass spectrometry, atomic absorption analysis, X-ray fluorescence spectrometry, and instrumental neutron activation analysis.

ENVIRONMENTAL GEOCHEMISTRY

Pesticides in Soils and Groundwaters

Procedures and Guidelines for Addressing Pesticide Contamination at Agrichemical Facilities The ISGS assisted the Illinois Department of Agriculture (IDOA) in responding to the 1990 amendments to the Illinois Pesticide Act, which requires the IDOA to develop guidelines and recommendations for the remediation of pesticide-contami-

nated soil and groundwater at the 1,200 agrichemical facilities in Illinois. The project was completed during the report period.

Fifty facilities were randomly selected; some soil samples from each of 49 sites contained detectable concentrations of pesticides. Of the pesticides detected, 20 were found in fewer than 1% of the samples. Most frequently detected were alachlor, atrazine, metolachlor, trifluralin, pendimethalin, cyanazine, metribuzin, metribuzin DA, butylate, and α -benzene hexachloride. These pesticides were also found at the greatest concentrations in the soil samples.

Pesticides were detected at all sampling depths; 50% of all pesticide detections were found in the gravel fill that serves as the parking lot and road base for each facility. No predictable pattern in pesticide occurrence in relation to sampling depth could be determined on the basis of mobility or persistence of the pesticide. Approximately 24% of the pesticide detections occurred in a concentration range between the detection limit and $50\mu\text{g/kg}$, and 79% of all detections were less than $1,000\mu\text{g/kg}$.

What level of remediation is needed? Soil-cleanup objectives for retail agrichemical facilities in Illinois will directly impact the cost of remediation. Soil materials at these facilities are apparently not subject to hazardous waste regulations. Of the 49 facilities, 11 appear to be in areas where the top of the uppermost aquifer material lies within 5 feet of ground surface. Very low pesticide concentrations may be required as soil-cleanup objectives for these facilities. Twenty-three of the 49 sites appear to be in areas where the potential for groundwater contamination from surface sources is low because aquifer materials are not present within 50 feet of the ground surface.

A four-core sampling scheme (one sample from each of four different depths at four different locations) was not adequate to assess the horizontal or vertical distribution of pesticides. A stratified random sampling strategy should be employed in which more samples are collected in areas where high concentrations are anticipated. Because most of the detections occurred in samples taken within 50 centimeters of land surface, a more cost effective way to define the horizontal extent of contamination would be to take more surface and shallow samples. Additional samples would be taken from selected depths in these areas.

Waste Management and Remediation

Codisposal of Coal Slurry Solids and Fluidized-Bed Combustion Residues In the fluidized-bed combustion of coal, fine grained coal and limestone are injected into the combustor simultaneously. The limestone traps sulfur dioxide generated during the combustion of sulfur-bearing components of the coal. Fluidized-bed combustion allows the combustion of Illinois high-sulfur coals without significant emission of sulfur dioxide into the atmosphere. However, the process generates large quantities of solid waste, primarily calcium sulfate and calcium oxide, an alkaline compound that eventually converts to calcium carbonate on exposure to atmospheric carbon dioxide and moisture. The waste also contains a component of



Geochemist William Roy checks soil materials at an agrichemical storage facility. Samples of the parking lot gravel-fill are being collected to test for the presence of pesticides.

coal ash. In central Illinois, this waste is generally disposed of by returning it to the mine from which the coal was purchased.

Pyrite in run-of-mine coal is partially removed during the coal cleaning process. Particles of pyrite are concentrated in the fine solids that are rejected as a slurry from the cleaning process. The slurry is usually discharged to an impoundment where the solids settle out and the water is drained off and recycled through the cleaning process. When the impoundment has reached capacity, or it is no longer used, it must be dewatered, covered with a 4-foot thick layer of topsoil, and revegetated. Oxidation of pyrite in the coal slurry solids can produce strong acids that leach into ground or surface water.

Both wastes must be either disposed of or used in some environmentally acceptable manner. This research is testing whether the two wastes can be disposed of together. As expected, we are finding that the alkaline components of the fluidized-bed combustion residue neutralize the acid produced by oxidation of pyrite in the coal slurry solid. When the two wastes are mixed together and in contact with water for an extended time, the resulting leachate contains elevated concentrations of calcium, sodium, sulfate, and chloride. The concentrations of most trace elements in the leachates are below detection limits, so they do not provoke environmental concern. A few elements, such as boron, molybdenum, arsenic, and selenium, are present in the leachates at detectable concentrations.

These elements might interfere with the germination and growth of plants that could be used in the revegetation of the codisposed materials. Future research will look at the germination and growth of three plant species in these materials.



Geochemists Jianqiu Cao and Keith Hackley inspect output from the mass spectrometer used for analyzing sulfur isotope ratios in geologic material.

Use of Environmental Isotopes for Identification of Landfill Gas and Leachate The Isotope Geochemistry Laboratory continued this research project, which has been funded by Waste Management Inc. of Illinois since 1992. Two contract reports were completed during the report year. All five isotopes tested, carbon-14, carbon-13, tritium, deuterium, and oxygen 18, were effective to some degree in tracking the movement of landfill gases and leachates. When the five isotopic signatures are used together, not only can landfill contamination be identified, but the mode of contamination—whether due to landfill gas or leachate migration—can also be differentiated. The latest findings are being developed into a new technique beneficial for use in monitoring landfills.

CHEMICAL ANALYSIS METHODS AND SERVICES

Direct Determination of Organic Sulfur in Coal and Coal-Related Materials by Combined Use of Low Temperature Ashing and Quadrupole Gas Analysis Two members of the Geochemistry Group and three members of the Energy and Mineral Resources Group collaborated on an ISGS-funded project to develop a method for directly determining organic sulfur in coal. After numerous experiments and design adjustments, the project culminated in a patent disclosure entitled, "Direct Determination of Organic Sulfur in Coal and Coal-Related Materials by Combined Use of Low Temperature Ashing and Quadrupole Gas Analysis." The disclosure passed initial review by Research Corporation Technologies and was selected for further evaluation and commercial planning.

TECHNICAL AND ADMINISTRATIVE SERVICES

A variety of technical and administrative services are necessary to support the operations of ISGS research and service and to deliver the results to our users. Internal functions include

- record keeping, accounting, budget planning, and other fiscal services required for ISGS operations;
- editing, illustrating, and assembling camera-ready copy of scientific and educational publications;
- maintaining and operating the buildings, scientific and technical equipment, and automotive equipment;
- designing and constructing customized laboratory and field equipment and instruments.

Special public services include

- disseminating publications, maps, and other information to the public, government, and media; helping the public to interpret and understand technical information as well as research and service activities;
- collecting and maintaining geologic records and samples for public use;
- educating through outreach programs, including field trips, workshops, and publications designed for school teachers, students, and the public.

SPECIAL PUBLIC SERVICES

Information Dissemination

For many people who visit, write, or phone the ISGS, a staff member in the Information Office is their primary contact. Phone calls averaged 1,000 per month on the main line into the Survey. More than 7,000 requests for maps and publications from 41 states were processed by office staff this year. Hundreds of topographic map indexes, lists of publications, and other complimentary information were also sent out. For fast delivery of maps and publications, the ISGS offers payment with Visa and MasterCard. During the first 6 months of 1993, more than 1,000 customers took advantage of this method of payment.

Orders for publications increased to 5,985 in FY93 from 5,065 in FY92. The demand for maps increased (table below), while the demand for publications decreased.

Distribution Statistics	FY92	FY93
ISGS publications	20,277	18,129
ISGS maps	2,376	4,284
ISGS blueline maps	2,214	2,383
USGS maps	22,371	29,6032

The Earth Science Information Center responded to 610 requests for geodetic and general cartographic information. New or revised editions of 92 maps in the 7.5-minute (1:24,000 scale) quadrangle series were released this year. Another 63 maps are in preparation for three separate USGS projects. Topographic maps are available for 45 of the 47 quadrangles that cover Illinois in the 30×60-minute series (1:100,000 scale). The two remaining maps authorized for this series are expected to be completed in 1994. At the 1:100,000 scale, 67 county maps have been published.



Joe Kaczanowski, maintenance supervisor, repairs the ISGS photographer's electronic flash equipment.

The Library and Map Room staff provide vital reference services to ISGS staff and visitors. Journals, acquisitions lists, and other materials are routed to notify staff of new publications and developments in their field. Citations are verified, bibliographies prepared, online literature searches run, and articles, books, and reports located and borrowed from libraries throughout the world.

The Technical Information Officer aided in the dissemination of information by helping others to interpret and understand complex technical issues. Contacts with the news media and trade presses were supplemented by press releases, fact sheets, feature articles, and other informational materials. The Technical Information Officer also attended technical workshops, conferences, fairs, expositions, and other public events to help explain the results of ISGS efforts. Considerable assistance was also provided to other ISGS staff members in coordinating and arranging for displays or exhibits portraying ISGS research and services at many other events.

ISGS Publications

High quality reports, maps, posters, slide presentations, field trip guides, and other materials related to the geology and mineral resources of Illinois are the primary products of the Publications, Graphics, and Photography Unit (table 2). ISGS publications inform and educate both the public and scientific communities. (See the separate section, *Publications*, which lists this year's releases.) The editors, artists, and photographer all contributed significantly to the success of ISGS publishing efforts this past year.

Table 2 Final publication projects^a

	1989-90	1990-91	1991-92	1992-93
Bulletins	0	1	1	2
Circulars	1	2	2	3
Environmental Geology Series	3	6	4	1
Cooperative Groundwater Reports	1	0	3	0
Illinois Mineral Series	2	3	2	2
Illinois Petroleum Series	1	2	2	3
Illinois Mine Subsidence Research (limited series)	0	0	0	0
Illinois Basin Studies (Consortium)	1	0	1	0
Special Report (new series)	—	—	^b 1	0
Guidebook Series	^b 2	^b 2	1	0
Contract Reports (discontinued series)	5	—	—	—
Open File Series (largely computer maps)	—	7	22	30
Directories of Coal Mines (new series)	—	—	—	1
Illinois Scientific Survey Joint Reports	2	0	0	0
Educational Extension Field Trip Guides	4	4	4	4
Papers, book chapters, misc. text (more than 5 pages)	15	21	15	18
Geogram	0	0	0	1
Large format maps, cross sections, stratigraphy columns	^c 0	12	16	7
Posters, displays, major slide presentations	25	20	21	27
Brochures, fliers, announcements of pubs	14	18	17	5
Administrative, miscellaneous, and <i>Geonews</i>	5	5	5	^d 6

^a tally of projects (published or unpublished), which are not all equal in size and complexity.

^b The special report and the guidebooks printed in 1989-91 were reprints of earlier publications. The 1992 Guidebook 24 is an original work.

^c includes 2 Quaternary Paducah quadrangle maps (OFS), 2 plates from B 100, IMaps 1 and 2, and 1 map set for American Oil Recovery, Inc. (through the Oil and Gas Section).

^d Includes Annual Report with Annexes, research highlights report, GSL catalog, HWRIC contract report, and 2 *Geonews*.

Geological Records and Samples Libraries

The Geological Records Library (GRL) is the repository for drilling records in Illinois, as mandated by statute (Illinois Oil and Gas Act – 225 Illinois Compiled Statutes 725/6(4)). The records are from oil and gas wells, water wells, engineering borings, and miscellaneous test holes. The database represents billions of dollars invested in Illinois for exploration and development of mineral fuels, groundwater, and engineering. The oil industry, coal industry, hydrogeologists, engineers, land-use planners, academic researchers, landowners, general public, and ISGS staff find the database a valuable resource.

During the report period, the GRL staff worked to reduce two backlogs of well information. The first was an accumulation of "grandfather" permits, the result of the Illinois Department of Mines decision in 1990 that all currently operating wells be permitted. Wells drilled before 1939, the year that permitting began, were included. In FY93, GRL staff completed processing and entering the last of the grandfather permits into the ISGS files.

In the second project, the backlog of water well records awaiting entry into the system was reduced to 4,269, and the number continues to decline. A total of 65,794 water well records has been added to the database since the backlog reduction program began in 1988. An active acquisition program of well information continues, as shown in table 3. Requests for water well data, especially for information to comply with various Illinois Environmental Protection Agency requirements, continued to increase. Note the 60% increase in requests for copies of the single sheets of well records. Demands for GRL services remained high, as shown in the total mail processed and the number of phone calls received. The number of visitors and the number of files used by the public and ISGS staff decreased.

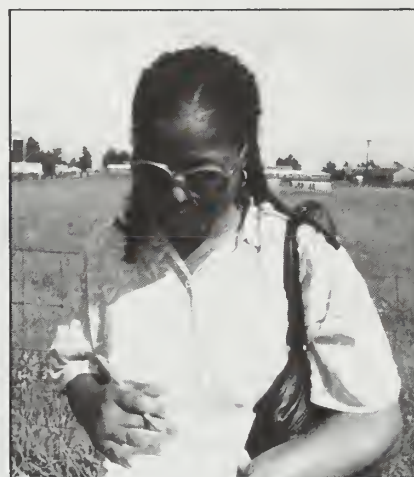
The Geological Samples Library (GSL) has one of the largest collections of geological samples in the United States. Mandated by statute (Illinois Oil and Gas Act – 225 Illinois Compiled Statutes 725/6(4)), this unique repository houses cores and cuttings that represent the billions of dollars invested in Illinois by petroleum, mining, and engineering companies. The collection attracts users from across the country, thus increasing the potential for in-state and out-of-state investment in Illinois. It also provides an essential physical database for investigating environmental and resource issues.



Thirty-five truckloads of core were delivered to the Natural Resources Studies Annex in Champaign. The cores not only provide the ISGS with an extensive data base on the geology of the entire Chicago area, but also form the foundation for future environmental, engineering, and mineral resources studies.

Table 3 Annual Statistical Summary for the Geological Records Library

	1991-92	1992-93
SERVICE ACTIVITIES		
Total mail processed	23,168	26,660
Visitor days	970	894
Files used by public and staff	45,637	39,581
Phone calls	3,558	3,638
Copies		
continuous logs	6,475	5,432
single sheets	38,706	61,489
Total orders processed	2,147	2,115
Copies to state agencies/staff		
single sheets	9,177	13,932
logs	219	329
DATA ACQUISITION		
Basic Data		
Oil permits	3,072	1,410
Water permits	8,449	9,334
Water task force records	10,388	6,142
Plugging affidavits		
oil	1,315	1,098
water	2,144	2,986
Logs		
Electric	515	465
Micro	179	179
Radioactivity	787	572
Miscellaneous geophysical	66	57
Total geophysical	1,547	1,273
Drillers	93	61
Drilling time	213	214
Company sample and core studies	24	49
Formation tops	94	167
General data (completion data)	1,348	1,116
Water well and test hole	5,966	7,521
Miscellaneous	977	784
Total new logs received	10,262	9,912
CUMULATIVE TOTALS THROUGH JUNE 30, 1993		
Collections	FY93	Totals
Processed drill hole records	7,112	349,138
Books of processed drill hole records	1	1,014
Skeleton logs (records prior to 1920)		17,920
Books of skeleton logs		40
Books of confidential logs		15
Books of out-of-state logs		14
Books of miscellaneous drill hole records		9
Geophysical logs	1,273	133,593
Coal plugging	813	23,487



Anne Latimer, editor on assignment for the ISGS *Geonews*, takes notes about donated cores from the Metropolitan Water Reclamation District of Chicago.

The GSL office at the Natural Resources Studies Annex also houses a microfiche collection of well log information—backup for the main GRL paper records.

Visitors and staff referred to GSL files 247 times in FY93 and studied 519 sets of samples or core. Visitors to the Annex facility represented a wide range of geologic interests, including independent consultants, major oil companies, universities, and government agencies. Of the 99 people who visited the GSL, 68% were from out of state, 20% were independent operators, and 79% represented companies, governmental organizations, or universities.

During FY93, 351 sets of well sample cuttings were added to the permanent file consisting of 226 oil test sets and 125 water well sets. The additions represent 538,481 feet of drilling, which increased the total drilling represented by the collections to 743,535,612 feet. The GSL files of 67,770 sets of well cuttings are stored in 104,310 boxes.

Samples from an additional 56 oil and water wells await processing. The interval between initial receipt of a set of samples and their placement in the permanent collection is 3 months, a reduction of 3 months in the processing time, as compared to last year.

Rock cores from oil and mineral borings added to the GSL during the report period increased the total drilled footage of core to 1,061,388 feet. During the report period, 177 cores representing an additional 61,388 feet of drilling were collected, examined, and processed into the permanent files that now consist of 13,801 sets of core.

To manage the limited space available for core storage in the GSL, a scientific review committee was formed this year. It will oversee and make recommendations regarding requests for acquisition and permanent storage of core by ISGS staff.

In September 1992, 35 truckloads of core stored in 9,350, 5-foot wooden boxes collected by the Metropolitan Water Reclamation District of Greater Chicago and housed at Skokie, were relocated to a site near the Natural Resources Studies Annex in Champaign. Scientific staff reviewed the collection to eliminate duplicate and noncritical samples. After review, the GSL staff, assisted by Administrative and General Services Group staff, relocated 7,237 boxes into the newly constructed, temporary core storage facility. Temporary collections in the permanent core storage building were also moved to this new storage facility, freeing up shelves for future storage of cores and samples in the main GSL facility.

Educational Extension

The ISGS prepares and distributes educational materials on the geology, mineral resources, and landscape of Illinois to elementary, high school, and college teachers, students, and the public. Major educational extension functions include conducting four field trips each year, participating in selected teacher workshops, and responding to requests for educational materials and general inquiries from teachers, students, and the public.



Old Stone Face (Caseyville Sandstone) overlooks the Eagle River valley, southeast of Harrisburg.

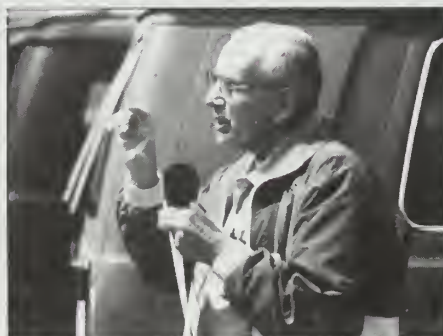
numbers of people to widely separated areas of Illinois. In September 1992, 220 people, including 37 teachers and 60 students, formed an 82-vehicle caravan to tour the area in the vicinity of Morris, Illinois. A highlight of the trip was a late-afternoon fossil-collecting stop in the world-famous Mazon Creek locality where fossils of Pennsylvanian plants and animals are exceptionally preserved in concretions. The Sparta field trip in October 1992 attracted 100 people, including 9 teachers and 18 students. Winding through the hills of southwestern Illinois, the 65-car caravan visited an oil field, three coal mines, limestone karst terrain, and an overlook of the Mississippi River at Fort Kaskaskia where the geologic history of the river was explained.

The first field trip of the spring season, held in April 1993 near Harrisburg, attracted 109 participants, including 13 teachers and 27 students. Highlights of the trip included a visit to the surface facilities at Kerr-McGee Coal Company's Galatia Mine, the faulted and sharply folded strata exposed at the Horseshoe Quarry near Cave Hill, and a view from the outcropping of the Pounds Sandstone known as the Old Stone Face.

For the second spring trip near Lewistown, the promise of fine weather and a region renowned for its scenic beauty attracted 220 participants, including 27 teachers and 52 students. Discussions for this trip emphasized the engineering geology of numerous landslides along the field trip route that had resulted from the exceptionally heavy rains in the area during the winter and spring.



School children (top) chip away at the outcrop. Field trip participants (above) line up for an interesting discussion by an ISGS tour guide at one of the stops. Chief Leighton (right) describes geologic features of the area.



CAPITAL DEVELOPMENT BOARD PROJECTS

Major capital development projects are currently in progress at the ISGS or were recently approved by the General Assembly and signed into law by Governor Jim Edgar. Of special note are approval for the Department of Energy and Natural Resources to purchase Burnham Hospital properties in Champaign for \$2.5 million, and release of funds to initiate a \$3.44 million program to renovate the Natural Resources Building that houses both the ISGS and the Illinois Natural History Survey (INHS).

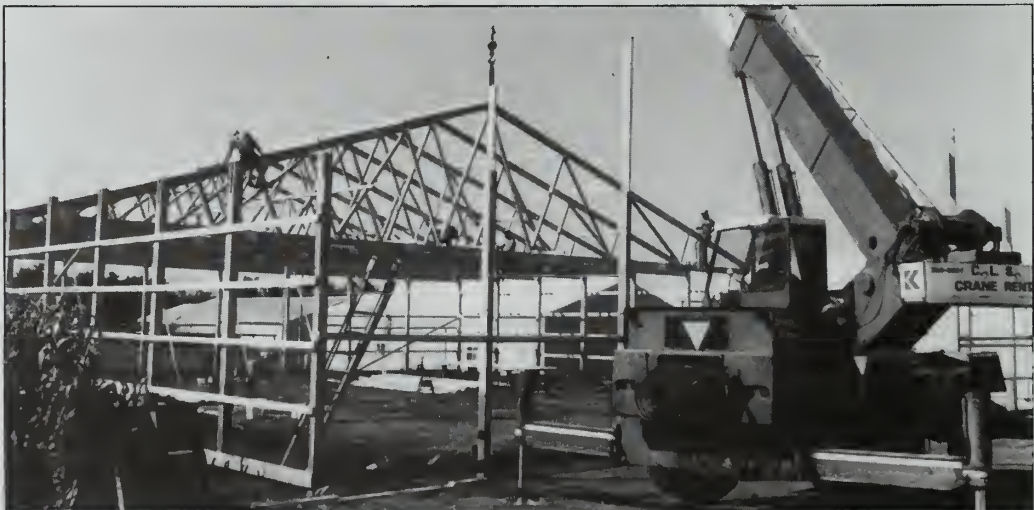
The purchase of Burnham Hospital will allow INHS to occupy that space after renovation. The ISGS will then expand into the space vacated by the INHS in the Natural Resources Building. Expansion of both Surveys into their new facilities will allow each to essentially meet the space requirements identified in an independent study of space needs conducted several years ago.

The \$3.44 million renovation project of the Natural Resources Building was initially approved in FY92. This is a joint project with the INHS to correct for existing safety hazards. Renovation work throughout the building is included. Construction began in July 1993 and is scheduled for completion in August 1994.

Also scheduled for FY94 is a \$2.66 million laboratory upgrade for the INHS portion of the Natural Resources Building. The ISGS will provide input to the INHS to ensure that the laboratories will be fully usable for geological and geochemical research after the NHS moves to the renovated "Burnham" facility.

Other capital development projects include the following:

- An FY94 appropriation of \$233,000 to be added to the FY93 appropriation of \$200,000 to correct safety and building code deficiencies at the Applied Research Lab. An additional \$500,000 has been requested for FY95 to complete Phase II of the project. Preliminary design on Phase I began June 15, 1993.
- The removal and replacement of a 1,000-gallon gasoline underground storage tank by the University of Illinois at a cost of \$43,500.
- Chimney masonry repairs for the Natural Resources Building by the University of Illinois. This project is to repair the two east double chimneys and includes replacing all split bricks, tuckpointing all brick joints, repairing chimney caps, reworking metal flashings, and applying masonry water repellent coating. This project is scheduled for completion in FY94 at a cost \$90,000.
- Construction of a 4,800-square-foot prefabricated metal pole barn on the south campus near the Annex to temporarily house the core from the Metropolitan Water Reclamation District of Greater Chicago and other samples. This work was completed in FY93 using funds administered by the University of Illinois.



Additional storage space was constructed to house the extensive collection of ISGS rock samples and cores.

ACTIVITY MEASURES

All Illinois state agencies are required to provide activity measures as part of their annual budget presentations to the General Assembly. Selected activity measures also are in the Governor's report on the state budget. Internally, we use a wide range of activity measures to gauge how effective we are at reaching the public with our information and services. The measures also are helpful indicators of where research and service staff are applying their greatest energies, and to what degree we may need to adjust or reshape our program, budget, or organization. Table 4 shows selected activity measures.

Table 4 Selected activity measures, 1992-93

	Energy and Mineral Resources	Geochemistry	Geologic Mapping and Framework	Groundwater and Environmental	Technical and Administrative Services	Total FY93	Total FY92
Reports and maps published distributed	111	39	66	59	16	291 24,796	396 22,653
Active projects	62	26	35	32	6	161	224
Visitors and office conferences	301	62	282	162	3073	3880	4135
Letters and unpub- lished reports	340	35	89	686	659	1809	1952

Some annual activity measures are calculated from samples taken for a few months; for example, the total number of long-distance telephone calls made by the staff is calculated from the total number of calls billed to the ISGS during September 1992, and February and May 1993. The number of phone calls and visitors recorded for the Information Office also have been based on samples counted for a short period of time. We believe that these estimates are sufficient for measuring trends from one year to the next.

Measures

Research Activities Our scientists reported 102 state-funded research and service projects in progress during the reporting year, 25 fewer than last year. Of these, 38 were in the area of Energy and Mineral Resources, 17 in Geochemistry, 25 in Geologic Mapping and Framework Studies, 16 in Groundwater and Environmental Geology and 6 in Technical and Administrative Services. Our scientists also reported 59 sponsored research and service projects active during the year, a decrease of 38 projects compared to FY 92. Of the 59 projects, 24 were in the area of Energy and Mineral Resources, 9 in Geochemistry, 10 in Geologic Mapping and Framework Studies and 16 in Groundwater and Environmental Geology. The number of active state-supported projects reported by our scientists is down by 20% compared to last year and the number of sponsored projects reported is down by 39%. These major reductions in the number of active projects reported demonstrate the cumulative impacts of the significant budget reductions suffered by the ISGS during the past three fiscal years. Presumably, the projects that remained active during FY 93 constituted our core program.

It is expected that the smaller number of active projects will eventually be reflected by a reduction in the number of maps and other documents produced and published by our scientists. However, in view of the lag between the completion of a manuscript by the authors and its formal publication, our activity measures may not show these

effects for a year or more. Most of the other activity measures that we report measure direct services we provide to the public rather than the size and quality of our scientific research programs. They appear to have been little affected by the staff reductions and budget cutbacks.

According to the count maintained by our grants and contracts administrative office, ISGS scientists submitted 67 proposals for external support of research investigations, 32 fewer than last year. Of these, 32 were submitted in the Energy and Mineral Resources area, 8 in Geochemistry, 5 in Geologic Mapping and Framework Studies and 22 in Groundwater and Environmental Geology. Many of the proposals we submit are prepared at the request of the sponsoring agency after preliminary negotiations are complete. Of the 67 proposals submitted in FY93, 38 were accepted by the sponsor and at least partially funded, 18 were rejected by the sponsor or withdrawn by the ISGS and 11 were still pending at the close of the fiscal year. This represents a success ratio of about 68% for the proposals on which a decision had been made by the sponsor.

To transfer the results of our investigations and service activities to the users, ISGS scientists prepare numerous reports, maps and other documents for publication in our own series or in other outlets such as scientific and trade journals, proceedings volumes and guidebooks compiled for scientific meetings. The authors and titles of these formally published documents are listed in the *Publications* volume of this annual report. The number of publications prepared this year, as shown in the table, is only about 75% of the number published last year, but about the same as the number released in FY91. The number of publications in FY92 appears to have been anomalously high, increased by large numbers of oil and gas development maps (24) and coal mine maps (73) released that year.

Information Responses To provide scientific information to those requesting it, the ISGS Library and Information Office reported sales of 6,752 copies of our books and pamphlets and 6,157 copies of our maps and cross sections. We also distributed 11,377 free copies of our books and 510 free copies of ISGS map products. The total of 24,796 documents distributed is 9.5% greater than last year. The number of books and pamphlets distributed fell by 10.6% compared to last year, but the number of map products distributed rose by about 180%. We also sold 23,269 copies of United States Geological Survey map products and distributed 6,334 free copies. The number of maps sold this year is almost 17% greater than last year and the number of free copies distributed is 160% greater than last year. The number of free copies distributed represents a catch-up in a backlog from normal free distributions of newly published USGS map products to public officials. The free map products distributed to state and federal agencies in connection with the calamitous flooding during the summer of 1993 will be recorded in FY 94 activity measures.

During the report period, 3,880 visitors came to the Natural Resources Building to seek scientific advice, discuss proposed activities, examine our voluminous files of scientific data and purchase copies of publications. The total is about 6% less than the number of visitors for FY 92 as shown in the table in this year's report. The number of visitors listed in last year's report was erroneously high because of an arithmetic error. As shown in this year's table, the correct total number of visitors in FY 1992 should have been 4,135. The total number of visitors to the Information Office rose from 1,641 in FY 92 to 1,857 in FY 93, an increase of about 13%. In FY 93, 894 visitors came to the Geological Records Library (GRL), compared to 897 in FY 92; 122 external visitors came to the Geological Samples Library (GSL) in FY 93 compared to 114 in FY 92. Visitors to the Samples Library examined 286 sets of samples.

To respond to inquiries and conduct ISGS business, our scientists reported sending out 1,809 letters and unpublished reports, 143 less than the total for last year. Offsetting this modest reduction in the number of letters and reports prepared was a 5% increase, to 34,200, in the estimated number of long distance telephone calls billed to the ISGS for

the year. The Information Office received 11,694 incoming phone calls in FY 93, up almost 26% over last year's total. Many of these incoming calls are directed to our scientists to provide a direct response to the caller. Telephone calls, facsimile transmissions of handwritten and typed materials, and computer messages and data transmitted directly through worldwide electronic networks are rapidly replacing letters and longer unpublished reports as the preferred means of transmitting unpublished information to our clients. Our current activity measures do not adequately track these new forms of communication.

Demand for copies of well logs and other records distributed by our Geological Records Library remained at about the same level as last year. The GRL sold 5,442 continuous well log copies, 20 fewer than last year, and 61,767 single-page copies of geological records (mostly water well logs).

Identifications and Analyses To carry out their research and service projects during the reporting year, ISGS chemists completed at least 31,459 separate elemental determinations on 847 samples of rock, soil, brine, and water. The Isotope Geochemistry Laboratory performed 5,044 separate isotopic determinations on 3,065 samples, completed 262 carbon-14 age determinations and made 3,060 determinations on 255 samples with the quadrupole gas analyzer. The Coal Analysis Laboratory completed 3,243 proximate, ultimate, hydrogen, sulfur and carbon analyses on 681 samples of coal and coal-related materials. The organic geochemistry laboratories performed 60 RockEval determinations on 20 samples, 4,240 determinations on 106 samples of oil and 2,320 determinations on 58 samples of oil source rocks. Other chemical determinations included 1,808 determinations of ^{14}C -labeled tracer chemicals in 802 samples with the liquid scintillation counter, 530 ion chromatography determinations on 116 samples and 557 immunoassay determinations for pesticide occurrence in 214 samples. Our scientists also completed 3,312 mineralogical determinations by x-ray diffraction and described 154 petrographic thin sections. They performed 928 elemental determinations with the energy dispersive x-ray analyzer while examining 124 samples in the scanning electron microscope and processed 24 samples of coal through the low-temperature ashing system. In the field and laboratory, our scientists measured 36 stratigraphic sections, described 93 cores and studies 125 sample sets. The palynology laboratory completed 40 biostratigraphic determinations. Geotechnical analyses included 56 instrumental particle size determinations on suspended sediments, 186 hydrometer tests, 211 sieve tests, 100 determinations of total suspended sediment content and 123 tests of rock strength. The reservoir engineering laboratory completed measurements of porosity and permeability on 20 core plugs, 100 minipermeameter measurements, 5 coreflow tests, 10 oil viscosity tests, 20 resistivity measurements, 5 pitot-tube gas flow tests and 2 isochronal gas flow measurements. A total of 12 natural gas samples were collected for analysis during the year.

To explore for groundwater and for other purposes, our scientists ran 62 borehole geophysical logs at 53 locations and conducted 52 electrical earth resistivity surveys. The staff of the Digital Cartography and Spatial Analysis Section and other staff members throughout the ISGS wrote 577 custom computer programs in various languages, completed 35 data-entry projects of various sizes, digitized 277 maps and plotted 1,210 copies of various digital map files for internal use or external distribution.

HONORS, AWARDS, AND PROFESSIONAL RECOGNITION

James W. Baxter Recognized by the Illinois State Geological Survey in October 1992, when he was presented with the Lifetime Distinguished Achievement Award.

Richard C. Berg Received the Illinois Groundwater Association Science Award for 1993, as recognition of his scientific contributions in support of the Groundwater Protection Act.

A Certificate of Appreciation was also presented to Dr. Berg by the Canadian Institute of Public Health Inspectors and the National Environmental Health Association at the 1992 International Environmental Health Conference in Winnipeg, Manitoba.

Subhash B. Bhagwat Recognized in *Who's Who in Finance and Industry 1993-94*, *Who's Who in the Midwest 1993-94*, and *Who's Who in Science and Engineering 1993-94*.

Ross D. Brower and Philip C. Reed Received special mention in a Certificate of Appreciation presented by the Fountain Public Water District in Monroe County, Illinois, to ISGS hydrogeologists for their work leading to the successful siting of production wells.

Jianqiu Cao, Keith C. Hackley, Donald J. Lowry, John Lytle, and Rodney R. Ruch Selected by Research Corporation Technologies to receive a monetary award for their patent disclosure on a process for the direct determination of sulfur in coal.

Michael J. Chrzastowski Elected 1993 chair of the Coastal and Shelf Sedimentation Research Group of the SEPM/Society for Sedimentary Geology.

A Letter of Commendation was also presented to Dr. Chrzastowski by the U.S. Army Corps of Engineers (Chicago District) for significant contributions to the Illinois Shoreline Interim III Report, which describes erosion problems and the need for major rebuilding along the Chicago lakefront.

Joseph A. Devera Awarded second place in the Best Poster competition at the 1993 Annual Meeting of the Geological Society of America.

The Sigman Xi Padgett Scholarship was also awarded to Mr. Devera for his outstanding accomplishments in research at Southern Illinois University in Carbondale.

Henry P. Ehrlinger III Selected by the Society of Mining, Metallurgy, and Exploration to receive their Distinguished Member Award.

David L. Gross Appointed 1992-93 chair of the Geology and Public Policy Committee of the Geological Society of America.

Ardith K. Hansel Elected to the Quaternary Geology and Geomorphology Division Panel of the Geological Society of America for the years 1992-94.

Richard D. Harvey Received the R.A. Glenn Award, presented by the ASTM Committee on Coal and Coke, in recognition of his many years of outstanding technical service.

Beverly L. Herzog Elected 1993 chair of the Illinois Groundwater Association, and recognized in *Who's Who of Emerging Leaders in America 1993-94*. She is also serving her second term as secretary of the Illinois-Indiana Section the American Institute of Professional Geologists.

second term as secretary of the Illinois-Indiana Section the American Institute of Professional Geologists.

Bryan G. Huff Elected 1993-94 president of the Illinois Geological Society, after serving as vice president and program director of the Society during 1992-93.

Hwe-Hwa Hwang Elected Sigma Xi member in 1993.

Myrna M. Killey Elected 1993-94 treasurer at the national level of the American Institute of Professional Geologists.

Timothy H. Larson Appointed 1992-94 co-chair for the Public Affairs Committee of the Engineering and Environmental Geophysics Society.

Morris W. Leighton Elected 1992-93 president of the Association of American State Geologists. Dr. Leighton's dedicated service as president, in fulfilling the objectives of AASG, was recognized with a plaque.

Donald F. Oltz Recognized by the Illinois State Geological Survey in October 1992, when he was presented with the Distinguished Achievement Award.

Dr. Oltz also served as 1992-93 vice president of the Eastern Section of the American Association of Petroleum Geologists.

Rodney R. Ruch Elected within the International Standards Organization to be chair and secretary of the technical committee on "Methods of Coal Analysis." The group of experts from 22 nations reviews and updates specific methods of coal analysis for use in trade.

Gary L. Salmon Recognized by the Illinois State Geological Survey in October 1992, when he was presented with the Outstanding New Staff Member Award.

Christopher J. Stohr Acknowledged by the Illinois Mapping Committee for his 6 years of service as secretary.

Technical Design, Operations, and Maintenance Unit Recognized by the Illinois State Geological Survey as the Outstanding Unit for 1992.

Colin G. Treworgy Awarded first place for his poster paper by the American Association of Petroleum Geologists at their Eastern Section Meeting, held in Urbana, Illinois, in September 1992. He also received the Vincent E. Nelson Memorial Award.

FINANCIAL REPORT

Fiscal Year 1993

Appropriated Funds Of the available appropriated FY93 funds totalling \$5,170,500 (Tables F1 and F2), the Illinois State Geological Survey expended all but \$100 (.002%) of General Revenue Fund appropriation and \$78,500 (31.3%) of the Natural Resources Information Fund appropriation. Expenditures in the Natural Resources Information Fund were intentionally light as revenues did not fully support the appropriation.

Allocated Funds Of the available allocated FY93 funds totalling \$255,200 (Tables F3 and F4), the Illinois State Geological Survey expended all but \$400 (.35%) of the available funds in the Lands Unsuitable for Mining Program. The Groundwater Protection Act - Hazardous Waste Research Fund was fully expended.

Table F1 FY93 Financial Statement for the Illinois State Geological Survey General Revenue Fund: July 1, 1992, through September 30, 1993 (\$ in thousands)

Line item	Original appropriation for FY93	Transfers	Vouchered to date	Outstanding obligations to date	Balance available for FY93
Personal Services	\$4,155.6	\$0.0	\$4,155.6	\$0.0	\$0.0
Retirement Contributions	235.7	0.0	235.7	0.0	0.0
Social Security Contributions	9.3	(1.0)	8.3	0.0	0.0
Contractual Services	90.2	6.8	97.0	0.0	0.0
Topomapping	17.4	0.0	17.4	0.0	0.0
Travel	35.7	(4.7)	31.0	0.0	0.0
Commodities	63.2	(11.5)	51.7	0.0	0.0
Printing	32.9	2.6	35.5	0.0	0.0
Equipment	34.7	0.1	34.8	0.0	0.0
Computer Based Research	47.9	(1.5)	46.4	0.0	0.0
Telecommunications	48.7	7.8	56.5	0.0	0.0
Operation of Automotive Equipment	31.6	3.5	35.1	0.0	0.0
GeoMapping - Other Expenses	22.5	0.0	22.4	0.0	0.1
Repair & Maintenance-Major Equip.	78.4	(2.1)	76.3	0.0	0.0
Repair & Maintenance-Building	16.3	0.0	16.3	0.0	0.0
TOTALS	\$4,920.1	\$0.0	\$4,920.0	\$0.0	\$0.1

Table F2 FY93 Financial Statement for the Illinois State Geological Survey Natural Resources Information Fund: July 1, 1992, through September 30, 1993 (\$ in thousands)

Line item	Available appropriation for FY93	Transfers	Vouchered to date	Outstanding obligations to date	Balance available for FY93*
Lump Sum - Operating Expenses	\$249.4	\$0.0	\$171.9	\$0.0	\$77.5
Refunds	1.0	0.0	0.0	0.0	1.0
TOTALS	\$250.4	\$0.0	\$171.9	\$0.0	\$78.5

* NRIF receipts are insufficient to expend the full appropriation amount
NRIF Receipts July 1, 1992, through June 30, 1993, were \$159.0

Table F3 FY93 Financial Statement for the Illinois State Geological Survey Lands Unsuitable for Mining
Program: July 1, 1992, through September 30, 1993 (\$ in thousands)

Line item	Available appropriation for FY93	Available allocation for FY93	Vouchered to date	Outstanding obligations to date	Balance available for FY93
PROGRAM					
Personal Services	\$62.7	\$62.7	\$62.7	\$0.0	\$0.0
Social Security Contributions	0.5	0.5	0.5	0.0	0.0
Group Insurance	9.6	9.6	9.6	0.0	0.0
Contractual Services	0.0	0.0	0.0	0.0	0.0
Travel	1.9	1.9	1.9	0.0	0.0
Computer Based Research*	25.0	25.0	24.6	0.0	0.4
Telecommunications*	0.5	0.5	0.5	0.0	0.0
Program Total*	\$100.2	\$100.2	\$99.8	\$0.0	\$0.4
ADMINISTRATION					
Personal Services	\$11.0	\$11.0	\$11.0	\$0.0	\$0.0
Retirement	0.0	0.0	0.0	0.0	0.0
Social Security Contributions	0.1	0.1	0.1	0.0	0.0
Group Insurance	2.4	2.4	2.4	0.0	0.0
Commodities	0.4	0.4	0.4	0.0	0.0
Administration Total	\$13.9	\$13.9	\$13.9	\$0.0	\$0.0
GRAND TOTAL	\$114.1	\$114.1	\$113.7	\$0.0	\$0.4

* \$21,925 has been added to this allocation to cover costs in support of the Department of Mines and Minerals

Table F4 FY93 Financial Statement for the Illinois State Geological Survey Groundwater Protection Act:
July 1, 1992, through September 30, 1993 (\$ in thousands)

Line item	Available appropriation for FY93	Transfers	Vouchered to date	Outstanding obligations to date	Balance available for FY93
Lump Sum	\$141.1	\$0.0	\$141.1	\$0.0	\$0.0
TOTALS	\$141.1	\$0.0	\$141.1	\$0.0	\$0.0

